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Quarterly R&I literature review
2023/Q3-4

R&I for skills and competitiveness



R&I PAPER SERIES
LITERATURE REVIEW



*Research and
Innovation*

R&I for skills and competitiveness

European Commission
Directorate-General for Research and Innovation
Directorate G — Common Policy Centre
Unit G.1 — Common R&I Strategy & Foresight Service

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R&I for skills and competitiveness

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Literature review

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INTRODUCTION

This literature review is developed by the 'Economics of R&I' team of the Chief Economist unit of DG Research and Innovation. It provides a brief summary of a selection of recent publications on R&I economics and policy. Contributors for this edition: Valentina Di Girolamo, Debree Gaele, Alessio Mitra (review coordinator), Jan-Tjibbe Steeman.

Competitiveness and skills development are a pivotal element in the contemporary global economy. Established decades ago, as key drivers of growth, their significance has only intensified. Notably, the surge in technological advancements necessitates a workforce that is not only skilled but also adaptable and competitive.

Industries across the spectrum are witnessing rapid transformations due to technological disruption, and remaining competitive entails maintaining an edge in creating, innovating, and delivering services and products. This is vital not just for businesses aiming to lead in their respective markets but also for nations seeking economic resilience and growth.

As the job landscape evolves, the demand for new and evolving skills increases. Employers now seek a combination of technical skills and soft skills such as problem-solving, critical thinking, and communication. The need for continuous learning and development is imperative to

keep pace with industry changes and technological advancements.

However, challenges remain prevalent. The skills gap in various industries poses a significant threat to competitiveness at both individual and national levels. This gap is often exacerbated by educational systems that do not perfectly align with market demands. Moreover, the pressures of competitiveness can lead to issues such as workplace stress and concerns over work-life balance.

This literature review seeks to provide a thorough analysis of the importance of competitiveness and skills in the modern economy, examining the challenges and opportunities they present from various angles. The aim is to offer insights into how individuals, organisations, and policymakers can navigate these challenges effectively to harness the full potential of a skilled and competitive workforce.



UNIVERSITIES AND ECONOMIC GROWTH

Agasisti, T., & Bertolotti, A. (2022). Higher education and economic growth: A longitudinal study of European regions 2000–2017. *Socio-Economic Planning Sciences*, 81, 100940

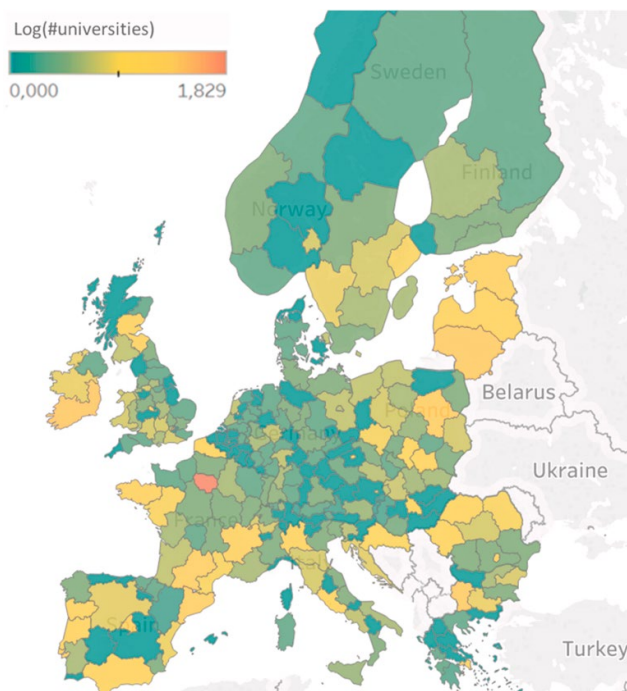
Messages

1. An increase in number of universities in a region is beneficial to stronger economic growth within that region. 2. The key drivers through which universities impact positively regions' economic development are the quality of research and a specialisation in STEM subjects.

This paper analyses the impact of the characteristics of regional Higher Education Systems (HES) on economic growth in European regions. HES are defined as a group of universities or academic institutions that operate within a given region.

The analysis is constructed with a dataset of 284 European regions (NUTS 2) of 30 European countries (i.e., the EU members including the United Kingdom, Norway, and Switzerland) over the period 2000–2017. The authors employ a sys-GMM econometric model that measures the potential contribution HES can have on regional economic growth through various channels, e.g., human capital and innovation. Eurostat, OECD, WHED, and InCites databases are used to create a dataset of regional economic and demographic data.

In line with previous studies, results show that an increase in the number of universities has a positive impact on economic growth in European regions. Interestingly, a higher effect is found when controlling for the universities' size, suggesting that regional growth is mainly led by HES' expansion in terms of size, rather than only number. Additionally, the paper highlights the importance of research quality and specialization in STEM for regional development, as



research output of higher quality positively affects regional GDP per capita, and the effect of the arrival of a new university in the region tends to be larger when the new university specializes in STEM subjects.

From a policy perspective, the paper offers interesting insights into the relationship between HESs and regional economies, providing policymakers with several recommendations to harvest economic development in their region, for example, through partnerships and programmes encouraging students and academics to engage in STEM activities.

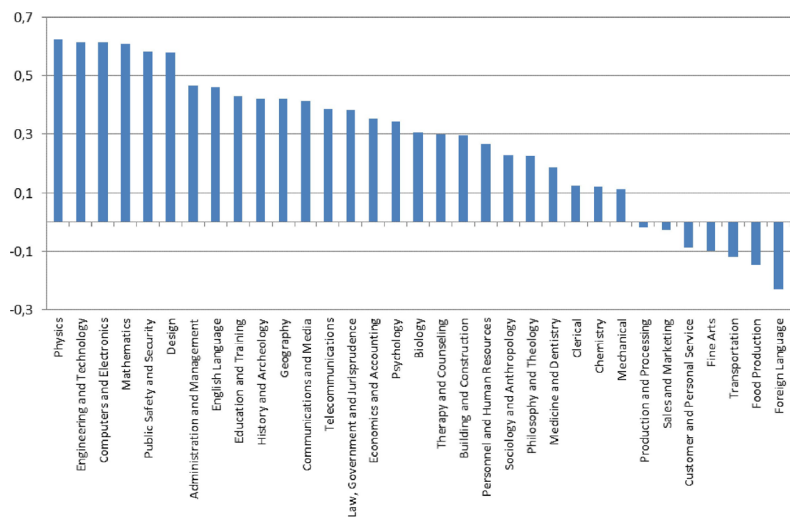
KNOWLEDGE AND SKILLS COMPLEXITY

Turco, A. L., & Maggioni, D. (2022). The knowledge and skill content of production complexity. *Research Policy*, 51(8), 104059.

Messages 1. Sophistication patterns and production complexity is a key driver for countries' long-term development and economic growth. 2. STEM knowledge and critical thinking are the most correlated skills to very complex goods' production. 3. Labour capabilities highlighted in this paper need to be targeted and fostered by policy makers in order to enhance competitiveness and economic growth. 4. Economic growth reflects more knowledge deployment than knowledge accumulation.

This paper analyses the labour skill and knowledge content of the product complexity measure, created by Hausmann and Hidalgo (2009). This indicator defines the complexity level of a good's production. The more diverse and exclusive the capacities required for production, the more complex the good is considered to be.

Industry Average Product Complexity and Knowledge Requirements Rank Correlation



Using data from IPUMS USA and IPUMS international databases, for both the United States and France at the NUTS3 level, the authors are creating a new indicator of occupational complexity. Finally, this new indicator is used to perform an OLS cross-sectional model in order to investigate the relationship between occupational complexity and GDP per capita.

The authors find that complex products are mainly concerning physics, engineering, and technology, computer electronics, and mathematics fields as well as jobs requiring science, mathematics, and critical thinking skills.

Concerning economic growth, they show that industries with a higher level of occupational complexity are experiencing higher real per capita GDP growth. In this paper, it is underlined that STEM and critical thinking skills and knowledge are transversal to all industries.

This paper fills a gap in the literature that did not explore the components of products' complexity yet. It reveals the importance of measuring complex goods' required labour capabilities for understanding countries' abilities to target and experience higher and stable growth. This is particularly useful for policymakers who can target and foster specific abilities within their region.

AI IN FUNDAMENTAL RESEARCH

Stephany, F., & Teutloff, O. (2024). What is the price of a skill? The value of complementarity. *Research Policy*, 53(1), 104898

Messages

- 1. The value of skills is influenced by supply, demand, and complementarity metrics;
- 2. AI skills exhibit a higher economic value than average skills;
- 3. Data-driven approaches can help enhancing occupational taxonomies and personalising skill development, thus improving labour market efficiency and reducing mismatches.

The paper proposes an empirical method to assign a market value to different skills, testing the extent to which a skill's value is determined not only by market forces of demand and supply, but also by its degree of complementarity with other skills.

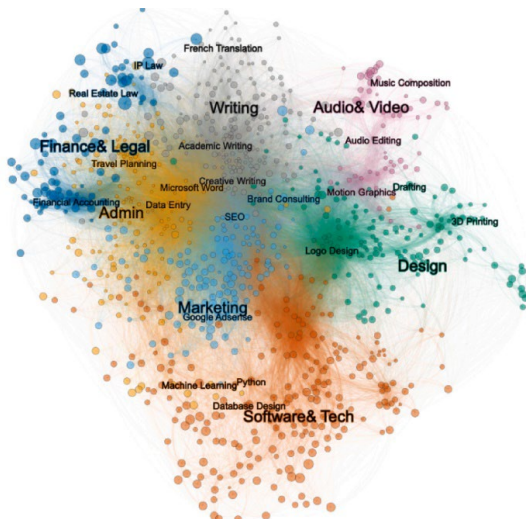
The authors argue that complementarity plays a central role in the reskilling process, as new skills are typically built leveraging on existing ones. Specifically, they postulate that the higher the degree of complementarity, the higher the value of the skill considered.

The analysis employs data on 49,884 US freelance projects between 2014 and 2022, retrieved from a popular online labour platform. A skill is defined as the competency a worker needs to perform a task. Using information on hourly wage associated to each project, the skill premium is calculated using a regression approach. Specifically, 962 linear

regression models (one for each skill) are estimated, controlling for supply and demand features of the labour market (proxied by using the number of workers commanding the skill and the number of projects requesting that skill, respectively), and three proxies of complementarities, capturing the number of adjacent skills, their diversity and value.

The analysis finds a strong correlation between a skill's value and its complements. Skills tend to be more valuable if frequently combined with a diverse set of highly valuable complements, as well as with skills from a different domain. Furthermore, the authors show that the skill premium associated to Artificial Intelligence (AI) skills (21%) is considerably higher than that associated to average skills (4%).

Additionally, the paper highlights the importance of adopting data-driven approaches to improve occupational and skill taxonomies, thereby helping better identify emerging skills and occupational clusters. By leveraging information from real-time data platforms, policymakers can provide personalised skill enhancement recommendations, enhancing labour market efficiency and reducing mismatches.



INTANGIBLES AND FIRMS PRODUCTIVITY

Roth, F., Sen, A., & Rammer, C. (2023). The role of intangibles in firm-level productivity—evidence from Germany. *Industry and Innovation*, 30(2), 263-285.

Messages

1. There is a strong and positive relationship between intangible capital and firm-level productivity 2. Non-R&D intangibles, in particular software & databases, firm-specific training have the greatest impact 3. The strong positive effect of R&D is limited to high-tech manufacturing.

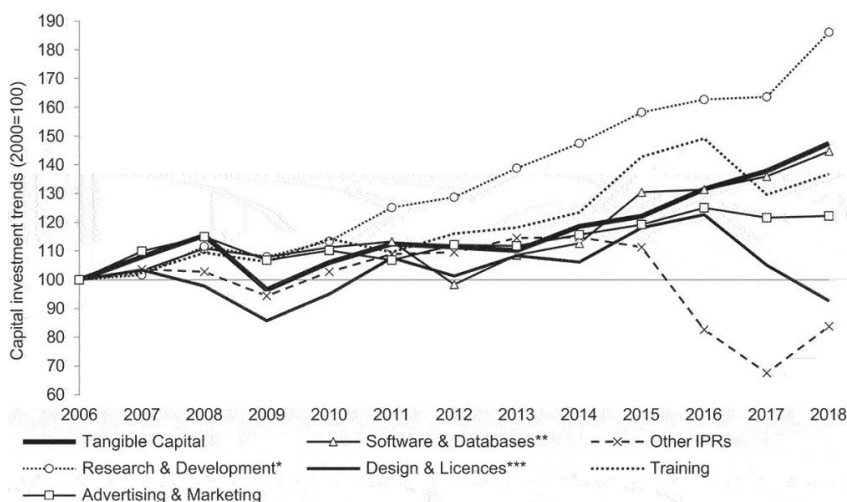
This paper analyses the impact of intangibles, such as software & databases, R&D, firm-specific training of employees, advertising & marketing, on firm-level productivity. The analysis looks at both goods-producing and service industries.

The analysis employs data from the German part of the Community Innovation Survey (CIS) for the period 2006 to 2018, and econometrics analysis to compute intangibles contribution to firm-level productivity growth in Germany.

Results shows a highly significant and positive relationship between intangible capital and firm-level productivity for Germany, similar to previous estimates for the EU as a whole. Specifically, the authors find that non-R&D intangibles such as software & databases, training, and advertising & marketing predominantly contribute to the positive effect of intangibles on the firm-level productivity. Although non-R&D intangibles are

important for both goods and services sector, they impact firm-level productivity more strongly in the services. Finally, it is also found that compared to economic competencies and software & databases, R&D does not have an equally strong effect on firm-level productivity. The only exception is in high-tech manufacturing, in which R&D is the most relevant driver of productivity.

From a policy perspective, the paper highlight that a competitiveness enhancing policy approach should go beyond supporting R&D, both through grants and tax incentives, as other intangibles are also major drivers of productivity, even often exceeding the role of R&D in many sectors, particularly in services. And the need of improving national accounting statistics to include all measurements of intangible assets.



DIGITAL SKILLS FOR THE GREEN TRANSITION

Santoalha, A., Consoli, D., & Castellacci, F. (2021). Digital skills, relatedness and green diversification: A study of European regions. *Research Policy*, 50(9), 104340.

Messages 1. To spur regional green diversification and speed up progress, policies should focus on enhancing digital skills and ICT infrastructures; 2. Digital competences can mitigate path dependencies by diminishing the reliance on existing know-how, enabling regions to new green diversification.

The paper explores the role played by digital skills in green diversification in European regions, comparing their relevance for the development of green versus non-green technologies.

Relying on the concept of relatedness (suggesting that regions diversify into new activities that share cognitive proximity with their existing know-how), the paper investigates (1) how relatedness foster green diversification compared to non-green one; (2) if digital skills foster diversification for green and non-green technologies; (3) whether digital skills moderate the relationship between relatedness and green and non-green diversification.

Data from OECD REGPAT, Regional Digital Economy and Society, Eurostat LFS, and ESCO databases, covering 142 European regions between 2006 and 2013, are analysed using a panel model. The dependent variable is a dummy taking value 1 if a given region not specialised in a technology at time t appears to be specialised in that technology at time t+1, and 0 otherwise. The explanatory variables of interest are indicators capturing the regional digital skills endowment, and degree of access to ICTs infrastructure.

The results confirm that related technological capabilities foster

the development of new technological specialisations, for both green and non-green technologies. However, non-green relatedness is more important for non-green diversification, while green relatedness is relevant for both. Moreover, digital skills positively affect regions' ability to specialise in new domains (with a stronger effect on green technologies), and reduce the importance of relatedness for both green and non-green diversification.

These findings highlight that digital competences hold the potential to speed up the decarbonisation process, suggesting that policies intended to foster green specialisation need to also integrate actions oriented to the creation and/or reinforcement of digital skills. By reducing the relevance of pre-existing know-how, digital competences can help counteract path dependencies, thereby providing new opportunities to foster regional diversification in different directions.

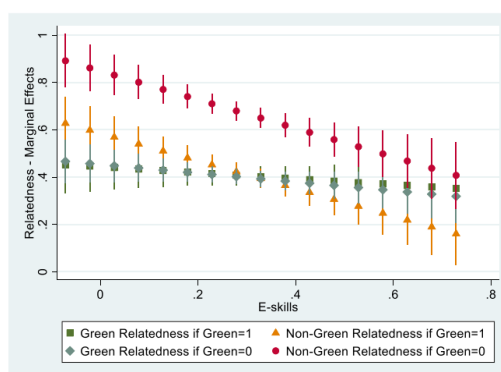


Fig. 3. Marginal effects of green and non-green relatedness on diversification at different quartiles of the e-skills distribution

IMMIGRATIONS AND SKILLS

Philipp Engler, Margaux MacDonald, Roberto Piazza, Galen Sher, (2023) The Macroeconomic Effects of Large Immigration Waves, IMF working paper

Messages

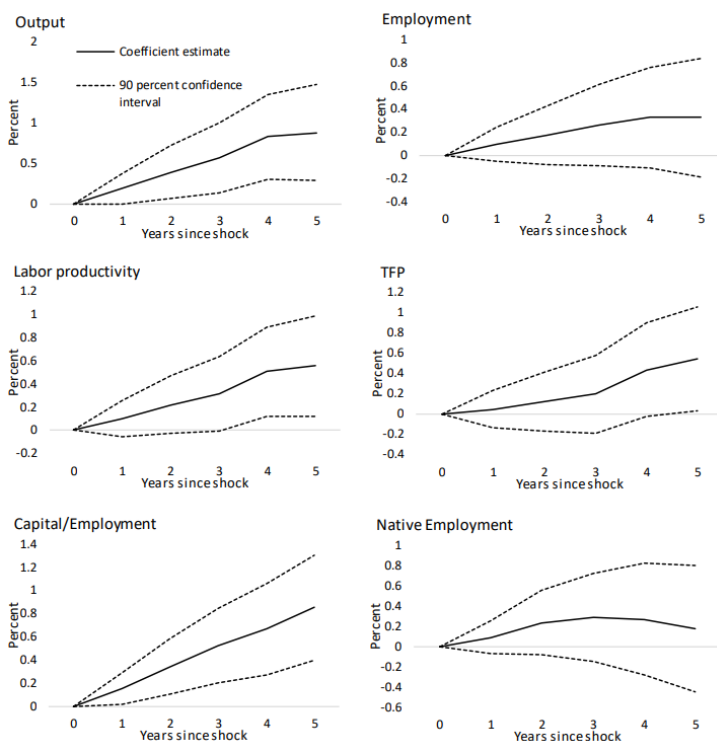
In advanced countries, large immigration waves raise domestic output and productivity in the host economy, with no negative effects on aggregate employment of the native-born population. 2. No macroeconomic effects on the host country are found for large refugee flows into emerging and developing countries.

This paper looks at the dynamic macroeconomic effects of immigration on the destination country. The analysis distinguishes the impact of immigration shocks in OECD countries from that of refugee immigration in emerging and developing economies.

Their analysis draws upon data for migration flows from the OECD, UN, and World Bank. The sample covers 34 countries with 229 shock episodes over the period 1981-2016 for the analysis of migration to advanced countries (OECD), and 137 countries with 179 shock episodes over the period 1981-2017 for the refugee analysis (emerging and developing economies). Macroeconomic variables are taken from various sources: Penn World Tables, IMF's WEO database, and OECD.

The study uses a novel approach to measure the dynamic economic effects of immigration on the destination country, combining the analysis of large immigration wave episodes with instrumental variable techniques.

Results show that in advanced countries, large immigration shocks raise output and



productivity in both short and medium term, providing positive gains for the host economy. Moreover, no evidence of negative effects on aggregate employment of the native-born population is found. These results, consistent with current evidence, provide evidence that migrant labour to advanced economies contain complementarities with that of the native-born population. On the contrary, no evidence of economic effects are found for refugee flows into emerging and developing countries.

EU GRANTS AND COMPETITIVENESS

European Commission, Directorate-General for Research and Innovation, Mitra, A., Niakaros, K. (2023). The Horizon effect : a counterfactual analysis of EU research & innovation grants, Publications Office of the European Union.

Messages **1. EU R&I funding promote firm level employment, revenue, and asset growth. 2. Companies in the “Information and communication” and “Professional, scientific and technical activities” NACE sectors are the most positively affected by the EU funding**

This paper looks at the impact of EU Research & Innovation (R&I) grants on financial firm-level outcomes including employment, assets, and revenue. The analysis investigates the impact of EU R&I funding as a whole and differentiating by economic sector.

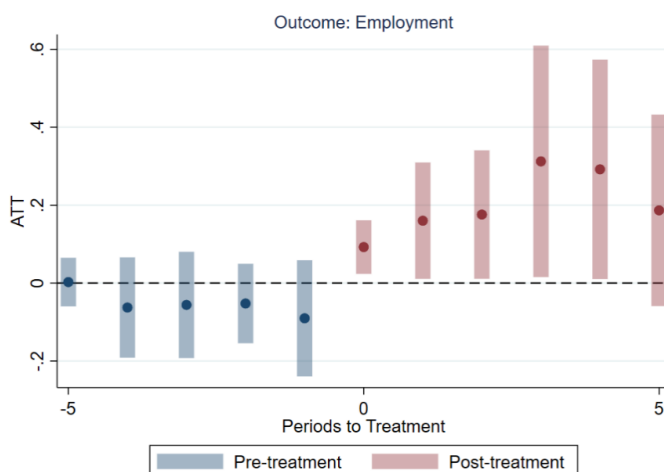
Their analysis draws upon administrative records from CORDA and financial data from ORBIS, spanning from 2010 to 2022. The study's core sample comprises approximately 40,000 unique privately owned companies that applied for Horizon 2020 grants. The Horizon 2020 Framework Programme for Research and Innovation, a cornerstone initiative of the European Union, was designed to foster and finance research and innovation endeavors in a wide array of scientific and technological fields. This flagship funding programme, operational from 2014 to 2020, supported not only entities within the EU member states but also extended its reach globally.

To infer causality, the authors rely on Difference-in-Differences (DiD) approach, accounting for staggered treatment timing and heterogeneous treatment effect.

Results show that Horizon 2020 fuelled a remarkable 20%

additional growth in employment and a 30% increase in turnover and total assets for participating firms compared to the ones that were unsuccessful despite high quality applications. However, this positive outcome was predominantly observed in firms operating within the “Information and Communication” and “Professional, Scientific, and Technical Activities” sectors. Firms in other sectors did not exhibit significant changes following the receipt of Horizon 2020 funding.

From a policy perspective, the results confirm the pivotal role played by EU R&I funding in enhancing EU competitiveness and fostering growth. Moreover, they prompt reflection regarding potential resource reallocation towards the domains that have showed the greatest efficacy, such as ICT and scientific and technical activities.



COMPETITIVENESS AND SUSTANANBLE ENERGY

Consoli, D., Costantini, V., & Paglialunga, E. (2023). We're in this together: Sustainable energy and economic competitiveness in the EU. *Research Policy*, 52(1), 104644.

Messages

1. Cross-country policy harmonisation is a necessary step towards the EU long-term goal of decarbonisation, the creation of a European green common knowledge space would align environmental, economic and competitiveness targets. 2. Countries with very high level of EEDs exports are increasingly gaining market shares in partner countries that are lagging in the energy transition. 3. Persistent lagging behind among less competitive economies may lead to greater technology gaps reducing market opportunities for fast-moving countries.

The paper explores the link between trade competitiveness and energy policy, focusing on the effects of domestic policy harmonisation and low-carbon energy targets on trade.

Using data from 19 EU countries from 1990 to 2015, it analyses how a country's policy instruments and policy mixes influence export competitiveness, employing a bilateral gravity model with sources such as the UN Comtrade database, OECD, and Eurostat to study exports in the energy efficiency devices (EEDs) sector.

The findings suggest that alignment of policy instruments significantly impacts trade performance, particularly showing that stringent energy policies lead to less dependence on the type of policy instrument used. Countries with lower energy taxation and strong public R&D in innovation attract more EED exports, while



those with higher taxation see increased domestic demand for efficient devices.

The research also reveals that a balanced and comprehensive policy mix enhances export capabilities, with trading partners drawn to markets noted for innovation.

Similarity in policy approaches among trading partners boosts EED exports. Additionally, variations in EED exports across EU states indicate that early adopters of clean energy gain a competitive advantage, although these leaders may encounter challenges from EU-wide policy convergence, affecting their market opportunities.

SKILLS SHORTAGES AND COMPETITIVENESS

European Commission. (2023). Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs and coordinated by the Directorate-General for Communication. Flash Eurobarometer 537 SMEs and skills shortages Report

Messages 1. Skill shortages pose significant challenges for SMEs, affecting their capacity to foster innovation and maintain competitiveness. 2. Confronted with skill shortages, organisations may face consequences such as increased workloads and diminished productivity.

The study reveals survey results regarding skill shortages and their impact on Small and Medium Enterprises (SMEs) as well as larger corporations across a variety of countries, including EU member states and non-EU countries like the US, Japan, Canada, and Switzerland. It underscores the vital importance of skilled labour in promoting innovation and competitiveness. Nonetheless, the growing gap between the demand for labour and the availability of skills presents difficulties for SMEs in recruiting suitable staff.

Within EU countries, the extent of the labour mismatch varies, with only 11% reporting ease in finding the appropriate workforce. Skill shortages manifest in various ways for SMEs, with reasons including a lack of applicants (56%), the absence of suitable candidates (54%), and the inability to offer competitive benefits in comparison to other employers (21%). In the context of skill shortages, certain roles within SMEs are particularly affected. Notably, there is a significant shortfall of technicians, with 33% of SMEs employing them and 42% reporting skill shortages. Furthermore, among SMEs employing

customer care experts, 23% report skill shortages. Additionally, SMEs experience pronounced skill deficits in areas such as R&D and IT, with 20% and 18% respectively finding it challenging to recruit qualified professionals.

These skill shortages have substantial repercussions for SMEs, with the most severe being increased workloads (48%) and loss of sales or difficulties in expanding sales (31%), followed by decreased profitability and growth (25%) and reduced productivity (25%). However, reduced productivity is cited as the second most significant impact for medium-sized companies (30%) and large companies (25%).

Previous initiatives to mitigate skill shortages have included enhancing working conditions, training/reskilling, retention efforts, and recruitment from abroad.

Q8 What impact does the skill shortage have on your company? (Multiple answers allowed) (% EU27)



Base: n=9 342 (SMEs) – Faced with a skills shortage

STI POLICY AND COMPETITIVENESS

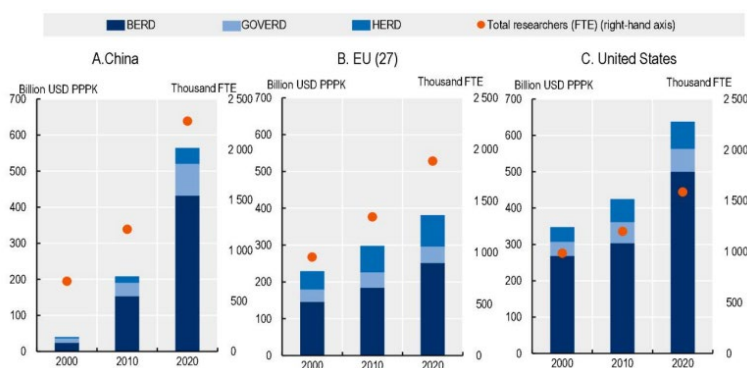
OECD. (2023). OECD Science, Technology and Innovation Outlook 2023. Enabling Transitions in Times of Disruption. (Chapter: Science, technology and innovation policy in times of strategic competition)

Messages **1. Research into Science, Technology, and Innovation (STI) plays a pivotal role in ensuring the competitiveness and resilience of an economy against various challenges. 2. The key policy actions adopted by nations to bolster technological sovereignty and strategic independence comprise a blend of protection, promotion, and projection.**

The study delves into recent and forthcoming trends within and surrounding STI domains and their ramifications for policymakers globally. Moreover, it scrutinises the rise of China innovation ecosystem, and escalating tensions over technological independence among competing economies.

The report outlines the trajectory of R&D expenditure since 2000, highlighting a significant rise in China's investment, underscoring its commitment to securing a leading position in the research and innovation arena. China's increased R&D spending has resulted in a surge in the number of researchers (2.28 million in 2020, compared to 1.89 million in the EU and 1.59 million in the US) and publications (7 million from China, compared to 500,000 from the US), although the number of researchers per capita still trails behind the US and EU.

OECD countries have traditionally held a competitive edge over emerging economies due to their pioneering role in scientific research and innovation. Nevertheless, China's rapid advancement in cutting-edge technologies, such as semiconductors and AI, has heightened



strategic rivalry. The report raises concerns about the erosion of long-held beliefs in cooperation and shared values within the scientific community, as more policy agendas pivot towards technological self-reliance and sovereignty. This paradigm shift threatens to disrupt existing technology and research ecosystems.

To bolster national technological capabilities and mitigate vulnerabilities, countries implement three principal policy measures. Protective actions include export controls and research security measures to limit technology transfer. Promotional strategies, such as industrial policies, are designed to bolster domestic capacities and diminish dependence on foreign suppliers. Projection efforts, encompassing international STI alliances and technical standards, encourage collaboration and diversify technology supply chains, rooted in shared values and interests.

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The “Quarterly R&I Literature Review” provides a brief summary of a selection of recent publications on R&I economics and policy.

The aim of the Review is to inform policymakers on the latest findings from the literature that links R&I economics to R&I policy.

The Literature Review, together with the Working Papers and the Policy Briefs, is part of the “R&I Paper Series” which serves as a repository of analytical papers that supports an evidence-based EU policy, for R&I and beyond.

Studies and reports

